https://doi.org/10.61308/DBOD8638

Technological evaluation and determination of the traits stability in breeding materials in the early generations

Zlatina Uhr[1], Teodora Angelova[1], Evgeniy Dimitrov[1], Rangel Dragov[2]*
Agricultural Academy, [1]Institute of Plant Genetic Resources "K. Malkov" – Sadovo, Bulgaria
[2]Field Crops Institute - Chirpan, Bulgaria
*E-mail: *dragov1@abv.bg*

Citation
Uhr, Zl., Angelova, T., Dimitrov, E., & Dragov, R. (2023). Technological evaluation and determination of the traits stability in breeding materials in the early generations. *Bulgarian Journal of Crop Science, 60*(5), 17-27.

Abstract
The experiment was carried out on an experimental field of Institute of Plant Genetic Resources "K. Malkov", Sadovo during the period 2016 - 2018. Nineteen common winter wheat lines and variety Sadovo 1 were studied, under the controlled trial conditions. The purpose of the research is technological evaluation and determination of the stability of traits in breeding materials in the early generations. The analyzes were carried out in a laboratory to assess the technological qualities of the grain. For the characterization of the studied lines, the following traits were taken into account: sedimentation value (SV) - using a 2% solution of glacial acetic acid (Pumpyanskiy, 1971); fermentation number FN - Pelshenke test (PT) by mixing a sample with live yeast in two repetitions (Pelshenke et al., 1953). The traits stability of breeding material was evaluated by the stability variances σi^2 and Si^2 according to Shukla (1972), the equivalency Wi according to Wricke (1962) and the criterion of phenotypic stability (Ysi) according to Kang (1993). The program product IPCSSVKYSI (Interactive program for calculating Shukla's stability index (Ysi), developed by Kang & Magari (1995) was used to determine the stability index. The highest value for the trait sedimentation value was reported for line RU 32/2072.73.74, followed by line RU 47/3504. With a high value of the trait fermentation number are the lines RU 32/2072.73.74, RU 91/1729; RU 93/1895 and RU 128/2900. The influence of the factors genotype, environment and their interaction on the phenotypic appearance of the studied traits has been significant. The following lines can be highlighted as valuable breeding materials: RU 32/2072,73,74 and RU 47/3504 (high value and stability of the traits of sedimentation value and fermentation number). RU 49/2300 (high value and stability of the trait sedimentation value). RU 91/1729 (high value and stability of the trait fermentation number) The listed genotypes can be successfully used in breeding and improvement work to create new and high-quality common winter wheat varieties.

Keywords: breeding lines; wheat; quality; technological evaluation

INTRODUCTION

The wheat is grown all over the world, from dry and hot to cool and rainy regions, in a wide variety of varieties according to the dietary traditions and climatic conditions of the given region (Ivanova & Kirchev, 2018). Wheat breeding in Bulgaria has over 100 years of history. At the beginning of the century, it was almost 100% Bulgarian breeding, as a traditional culture for the country, but recently there has been a trend of entering the production of foreign varieties with a rich and diverse variety composition. (Kirchev & Delibaltova, 2016; Chamurliyski et al., 2016).

In addition to increasing the nutritional value of the obtained products, the quality of the wheat is important for determining the economic value of the grain. It is determined by a set of traits determining its biological value (physicochemical, technological and biochemical indicators for evaluating the grain). For each variety, their values are genetically determined, but are influenced by the applied agricultural techniques, climatic factors during the vegetation and the specific agro-ecological conditions of the area where it is grown. (Tsenov et al., 2013; Tsenov et al., 2015; Semenov et al., 2016; Ivanova & Kirchev, 2018; Nazarenko et al., 2020).

The problems with the quality of the harvested grain still require great effort from the breeders. Due to the negative correlation between grain yield and its quality. Improving it is a major goal of many of their programs. (Boyadjieva, 1994; Carson & Edwards, 2009; Taghouti et al., 2010; Kaya & Akcura, 2014).

In this regard, the role of plant genotypes with high ecological stability and plasticity is increasing. Undoubtedly, it is very difficult to combine productivity potential, quality and adaptability to environmental conditions in the given genotype. Therefore, not all of them have valuable characteristics that meet the requirements for grain yield and quality. Therefore, it is very important to have developed varieties with sustainable and valuable economic characteristics. (Iwaki et al., 2011; Moskalets & Rybalchenko, 2015; Chamurliyski et al., 2016; Ivanova & Kirchev, 2018; Uhr & Samodova, 2020). For each of the genotypes, depending on the specific soil-climatic conditions of the area and the agrotechnical factors, the values of these indicators are genetically determined (Koteva & Stoeva, 1996; Ivanska et al., 2021).

Climatic changes over the years are the reason that the underlying genetic quality of the varieties is almost always lower. Therefore, there is a need to create varieties with a "reserve" of high grain quality, which, even in the event of its lowering, will meet the requirements of group A. (Atanasova et al., 2010; Tsenov et al., 2011). According to Uhr et al. (2021) an objective evaluation of genotypes that enter the final stages of research, as well as of new-to-production varieties, can be obtained by evaluating yield stability and of traits characterizing the quality of wheat.

The stability of weather conditions in the critical stages of plant growth and development is of the greatest importance for the formation of a high yield and quality of the grain. (Rangare et al., 2010). It also gives us an estimate of the ability of varieties to develop their genetic potential under a wide range of conditions (Annicchiarico, 2002). Adaptation of varieties and their stable manifestation in terms of yield and quality indicators in wheat is one of the main goals of many breeding programs. (Parveen et al., 2010; Stoyanova et al., 2020; Bondarenko & Nazarenko, 2020; Uhr et al., 2021).

The sedimentation value (the sedimentation index) is an indirect method, by whose expression we can judge the quality of the flour, and therefore of the grain. The simplicity of the precipitation method (swelling of flour in a 2% acetic acid solution) and its low cost enable us to use it for a large volume of materials. In particular, in the breeding process, when many genotypes are analyzed in the early years of study.

In this aspect, evaluating the grain quality of common winter wheat by the sedimentation method allows us a more efficient selection of genotypes in the hybrid populations for grain quality in the early stages of the breeding process, where this indicator is recognized as essential in determining quality on the grain. It is highly heritable and shows carriers of quality genes (Kovtun, 2006; Zecevic et al., 2009; Kazartseva et al., 2010; Pshenichnaya, 2015; Sandukhadze, 2016; Pshenichnaya & Dorokhov, 2017; Davidyants & Eroshenko, 2017; Galushko et al., 2019; Gromova et al., 2020; Galushko et al., 2021; Galushko & Sokolenko, 2021). With an increasing need to search for starting material among the wide variety of genotypes in the breeding early stages for the creation of new high-quality varieties, the joint consideration of the trait sedimentation value together with fermentation number of Pelshenke (Pelshenke et al., 1953) would give us a clearer an idea of the magnitude of their values for the interdependence between gluten quality and quantity. Determining the interaction of environmental conditions and their stability allows us to more accurately select genotypes with good quality traits. (Hermuth et al., 2019; Angelova et al., 2020; Galushko & Sokolenko, 2021).

The purpose of the research is technological evaluation and determination of the stability of traits in breeding materials in the early generations.

MATERIAL AND METODS

Location of the experiment - The experiment was carried out on an experimental field of IPGR "K. Malkov", Sadovo, longitude and latitude:

24.9394681, 42.1309052, during the period 2016, 2017 and 2018. A detailed meteorological characteristic of the period was made. Nineteen lines of common winter wheat, obtained by intervarietal hybridization, and variety Sadovo 1, under the conditions of a control variety test, were studied.

The evaluation of the quality traits was carried out in a technological laboratory of IPGR, Sadovo. To characterize the grain of the studied lines, the following traits were taken into account:

-Sedimentation value, cm^3 (SV) – the Pumpyanskiy method is based on the principle of swelling of the protein fraction in an acidified environment. A 2% solution of ice acetic acid was used (Pumpyanskiy, 1971);

-Fermentation number (min) - Pelschenke test (FN) is based on the retention of CO_2 gases released during dough fermentation. A 10 g sample of grain meal was mixed with yeast solution (a biological product representing a concentrated mass of yeast of the *Saccharomyces cerevisiae* species) in two replicates (Pelshenke et al., 1953). The experiment was carried out under controlled conditions (30 °C - water thermostat). The longer the retention time of the sample on the water surface, the better the gluten quality.

Mathematical data processing - Data analysis

- Analysis of variance (Anova) - through the analysis of variance, the influence of the genotype, weather conditions and their interaction on the studied indicators was determined.

- The stability of breeding material traits was evaluated by the stability variances σi^2 and Si^2 according to Shukla (1972), the equivalence Wi according to Wricke (1962) and the criterion of phenotypic stability (Ysi) according to Kang (1993). The program product IPCSSVKYSI (Interactive program for calculating Shukla's stability index (Ysi), developed by Kang & Magari (1995)) was used to determine the stability index.

RESULTS AND DISCUSSION

Meteorological characteristic during the years of the study:

The temperature and the amount of precipitation, as well as their distribution during the growing season and during the filling and ripening period of the grain, have a great influence on the growth and development of wheat. Due to climate change and especially the negative effects of global temperature changes, deviations in wheat production and yield are observed worldwide (Vogel et al., 2019). The impact of climate change is also essential for wheat quality (Stoeva et al., 2006; Atanasova et al., 2009; Mohan & Gupta, 2016; Nazarenko et al., 2020).

The type of soil, the supply of nutrients, fertilization also affects the grain quality. Agrotechnical measures - tillage and precursor have an indirect influence on the changes in the stock of nutrients. (Popov & Dimitrov, 1979; Filipov, 2004; Jaskulska et al., 2013; Antonov, 2017).

We can define the 2015/2016 harvest year as "atypical" in agro climatic terms. Rainfall in the second ten days of October (Figure 2) delayed sowing and it was not carried out in the optimal terms. Recorded average monthly temperatures (Figure 1) during the winter period are above normal compared to multi-year temperature data, and precipitation is close to normal. The interphase periods for plant development (elongation - heading - flowering) were shortened. During the flowering period, the high temperature and air humidity shorten the pollination period. Low crops are formed.

After the pollination period, the most important stages for grain quality occur. It is fertilization, filling and maturation are crucial. The interphase period from flowering to milk maturity took about 20 days. Wax maturity occurred at near-normal mean daily air temperatures. Full maturity was recorded in the middle of June (between 17 – 26. VI). The high average monthly temperature for the month of June (23.09 °C) and the minimum amount of precipitation in the second (2.4 mm) and third ten days (6.6 mm) helped to form a high protein content in the grain, which is evident from the results for the year. The insignificant amount of rainfall during the last ten days of June and the first ten days of July did not affect the harvest campaign. Moisture at harvest was within the requirements of 13.0%.

For the harvest year 2016-2017, we can say that the climatic conditions allowed for quality tillage and sowing at the end of the optimal term.

Recorded low temperatures in November and December 2016 and average monthly air temperatures in January and February 2017 close to normal (Figure 1) combined with abundant snow cover until February 15 (2017). Under these conditions, late emergence was reported on February 21. This led to a shortening of all interphase periods and the formation of a lower than typical plant height. Precipitation in March was below normal (by about 20 mm), and average monthly temperatures compared to multi-year values were higher.

Very quickly, by the first ten days of May, at temperatures close to the norm and a very good supply of moisture (+26.2 mm), the heading and flowering phases passed. The interphase period from flowering to milk maturity takes 10 - 15 days. Waxy maturity was noted in the third ten days of June, and full maturity was recorded at the end of June and beginning of July. The dry and warm weather and minimal rainfall at the end of June and beginning of July did not hinder the harvest campaign.

The harvest year 2017 - 2018 in agrometeorological terms is also "very different". Tillage was hampered by the rainfall in October (84.6 mm). Sowing was done at the end of the optimal period. Germination was reported at the beginning of November (3.11.2017). Plant development proceeded normally under suitable climatic conditions for vernalization. The winter was mild (Figure 1).

The heading and flowering phases have almost merged because of the warm weather. Full maturity was recorded in the third ten days of June. Due to heavy rainfall during the period 26 to 29 June (94.9 mm) and the beginning of July (51.3 mm), the harvest was delayed and the quality of the grain deteriorated. Secondary weeding of the crops was obtained. The monthly amount of precipitation for the month of June was 139.9 mm, for the first ten days of July it was 51.3 mm. The harvest campaign was very difficult. Crops were blown away by the strong winds and harvest losses were reported.

For the three harvest years, we observe an increase in average monthly temperatures compared to multi-year data. The amount of precipitation is unevenly distributed, and in October, November, December and the month of May there is a decrease in the amount of precipitation compared to multi-year data.

Express methods of analysis, sedimentation value (Pumpyanskiy, 1971), Pelshenke fermentation number (Pelshenke et al., 1953) are extremely important for breeding. The magnitude of their values can be used to judge the relationship between the quantity and quality of gluten.

Sedimentation value

The maximum, minimum and average value by year is lowest in the last crop year. They are highest in 2017, when during flowering and pouring of the grain the conditions for development are close to optimal, combined with the warm and dry weather in June led to the formation and accumulation of quality protein. The variation of the trait is strong both

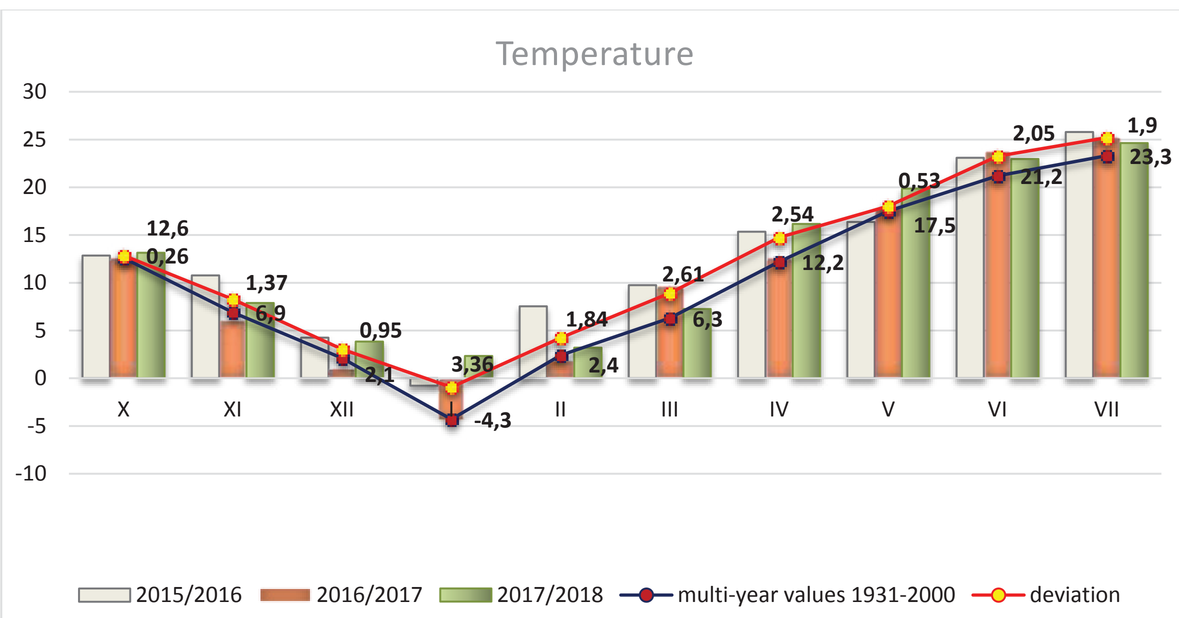

Figure 1. Temperature for the period 2015-2018 compared to multi-year data

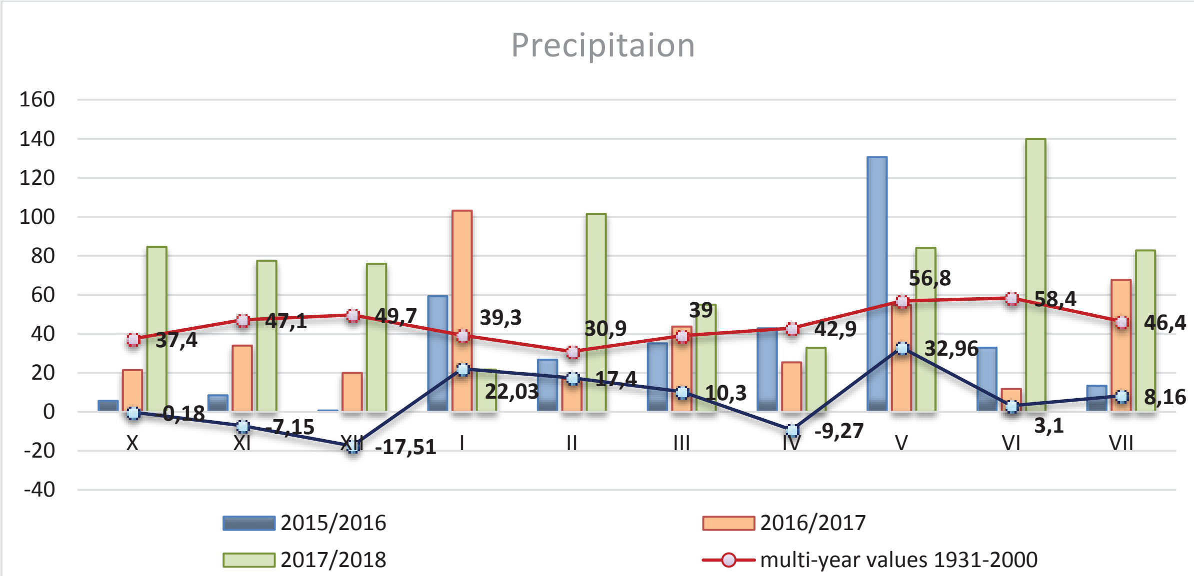

Figure 2. Precipitation for the period 2015-2018 compared with multi-year data

Technology Assessment

Table 1. Values for Sedimentation value

№	Variety	Sedimentation value, cm³					
		2016	2017	2018	$\bar{x}$	± D	Sign.
1	Sadovo 1-st	52.3	64.0	34.3	50.2		
2	RU 33/3244	52.0	48.7	45.0	48.6	-1.7	--
3	RU 79/1419	26.7	44.3	18.0	29.7	-20.6	---
4	RU 47/3504	51.3	63.0	51.7	55.3	+5.1	+++
5	RU 76/1321	36.7	62.0	16.3	38.3	-11.9	---
6	RU 49/2300	52.3	54.7	43.7	50.2	0.0	n.s.
7	RU 129/3053	45.0	53.0	40.0	46.0	-4.2	---
8	RU 48/2553	49.0	41.3	25.3	38.6	-11.7	---
9	RU 76/1332	38.7	38.7	26.7	34.7	-15.6	---
10	RU 79/1370	27.0	48.0	28.0	34.3	-15.9	---
11	RU 47/2852	64.0	42.3	29.7	45.3	-4.9	---
12	RU 91/1748	20.3	35.7	22.3	26.1	-24.1	---
13	RU 79/1373	40.3	41.7	20.3	34.1	-16.1	---
14	RU 128/2900	55.7	37.0	44.7	45.8	-4.4	---
15	RU 77/878	30.0	43.0	23.3	32.1	-18.1	---
16	RU 82/1476	32.0	37.7	22.3	30.7	-19.6	---
17	RU 79/1383	34.0	42.3	27.7	34.7	-15.6	---
18	RU 91/1729	36.7	46.0	25.0	35.9	-14.3	---
19	RU 93/1895	48.0	52.3	46.7	49.0	-1.2	n.s.
20	RU 32/2072.73.74	54.3	82.0	55.3	63.9	+13.7	+++
Mean		42.3	48.9	32.3	41.2		
Minimum		20.3	35.7	16.3	26.1		
Maximum		64.0	82.0	55.3	63.9		
Stand. deviation		11.8	11.6	11.9	9.8		
Coeff. of variation		27.8	23.8	36.8	23.9		
Stand. error of mean		2.6	2.6	2.7	2.2		
GD 5.0% = 1.3							
GD 1.0% = 1.7							
GD 0.1% = 2.1							

+ -,+ + - -,+ + + - - -, significant at GD 5.0%, GD 1.0% and GD 0.1%; n.s. – unsignificant by year and over the three-year study period. This is a result of the diversity of genotypes involved in the study. It is clear from the data (table 1) that for the studied period the average values of the indicator are within wide limits from 26.1 cm^3 for line RU 91/1748 to 63.9 cm^3 for RU 32/2072.73.74. Two of the genotypes (RU 32/2072.73.74 and RU 47/3504) have a proven difference above the standard (GD 0.1% and exceed the minimum requirements of Variety testing executive agency, approval and seed control for group A (50 cm^3). 15 of them have been proven below the standard.

Fermentation number.

The highest values of the trait were obtained in 2018 (141.5 min). The lowest maximum and minimum values were reported in 2017. In 2016, the highest minimum value was recorded - 58.3 min. The results of the conducted research show that the average values for the period of the indicator fermentation number are in a wide range from 68.6 min for Sadovo 1 to 185 min for line RU 91/1729. The average value was 118 min (Table 2). We have statistically significant differences with the standard for all 19 lines. 73.68% of them exceed the

Table 2. Values for Fermentation number

№	Variety	Fermentation number, min					
		2016	2017	2018	$\bar{x}$	± D	Sign.
1	Sadovo 1-st	58.3	49.3	98.0	68.6		
2	RU 33/3244	87.0	33.3	121.3	80.6	+12.0	+++
3	RU 79/1419	119.0	71.0	85.0	91.7	+23.1	+++
4	RU 47/3504	80.0	205.0	222.7	169.2	+100.7	+++
5	RU 76/1321	150.7	70.0	174.7	131.8	+63.2	+++
6	RU 49/2300	103.3	39.3	184.3	109.0	+40.4	+++
7	RU 129/3053	98.0	78.3	152.0	109.4	+40.9	+++
8	RU 48/2553	118.3	91.0	171.0	126.8	+58.2	+++
9	RU 76/1332	100.3	85.0	122.3	102.6	+34.0	+++
10	RU 79/1370	119.3	64.0	179.7	121.0	+52.4	+++
11	RU 47/2852	137.0	45.0	52.3	78.1	+9.6	+++
12	RU 91/1748	137.3	60.7	55.0	84.3	+15.8	+++
13	RU 79/1373	134.0	91.0	95.0	106.7	+38.1	+++
14	RU 128/2900	167.0	133.7	162.0	154.2	+85.7	+++
15	RU 77/878	151.0	65.0	161.3	125.8	+57.2	+++
16	RU 82/1476	98.0	49.0	134.0	93.7	+25.1	+++
17	RU 79/1383	140.0	79.3	115.7	111.7	+43.1	+++
18	RU 91/1729	219.0	158.0	179.0	185.3	+116.8	+++
19	RU 93/1895	141.0	117.0	141.7	133.2	+64.7	+++
20	RU 32/2072.73.74	144.3	165.0	222.0	177.1	+108.6	+++
Mean		125.2	87.5	141.5	118.0		
Minimum		58.3	33.3	52.3	68.6		
Maximum		219.0	205.0	222.7	185.3		
Stand. deviation		35.3	46.1	48.6	33.2		
Coeff. of variation		28.2	52.6	34.3	28.1		
Stand. error of mean		7.9	10.3	10.9	7.4		
GD 5.0% = 2.3							
GD 1.0% = 3.0							
GD 0.1% = 3.9							

+ -,+ + - -,+ + + - - -, significant at $P<0.05$, $P<0.001$ or $P>0.05$; n.s. – unsignificant requirements of Variety testing executive agency, approval and seed control (100 min for group A). During the three years of study, four of the lines (RU 32/2072.73.74; RU 91/1729; RU 93/1895; RU 128/2900) were distinguished by high values of the trait. The variation between years and average over the period is high. The coefficient of variation for both traits is high 23.9% and 28.1%.

Data analysis

Analysis of variance (Anova).

To establish the influence of the sources of variation, a variance analysis was performed (table 3). The results show proven influence of genotype, environment and their interaction. The strength of influence of the genotype is decisive for both indicators. It is responsible for 51.5% and 45% of the total variation for SC and SC respectively. The influence of other factors is less pronounced. For the sedimentation number, 26.1% is for the environment factor, and 22.2% is for the genotype-environment interaction.

In the other studied trait, 21.9% of the variation is due to the environment, and 33.3% to the genotype-environment interaction. To obtain high values of both indicators, it is necessary to select the appropriate variety and the environmental conditions to be the most suitable for the accumulation of quality protein. The obtained results are similar to our previous studies (Angelova et al., 2020).

To assess the stability of the traits of sedimentation value and fermentation number of the studied breeding materials, the stability variances σi^2 and Si^2 according to Shukla, the ecovalence Wi according to Wricke and the stability criterion YSi according to Kang were calculated. The lines showing lower values of the indicators σi^2, Si^2 and Wi are evaluated as more stable, and the higher the values of the indicator, the more unstable the respective genotype. The presented results (table 4) for the trait sedimentation value show us that line RU 47/2852, followed by lines RU 76/1321 and RU 128/2900, is the most unstable according to the criteria of stability σi^2, Si^2 and equivalency Wi. The presented lines show instability of linear and non-linear type - mathematically significant values of σi^2 and of Si^2. They are characterized by relatively large differences in the values of the trait sedimentation value during the years of research. The lines RU 82/1476, RU 79/1383, RU 91/1729, RU 129/3053 and RU 49/2300 stand out among the breeding materials with high stability of the trait sedimentation value. In them, the calculated stability variances (σi^2, Si^2) and Wricke equivalence (Wi) are high, and no great differences are observed between the values of the trait in the individual years of the study.

Important information about the value of individual genotypes is provided by Kang's YSi stability criterion. It simultaneously evaluates both the values of the studied trait and its stability. This cri-

Table 3. Influence of the sources of variation on the studied traits (Anova)

Traits	Sources of variation	SS	df	MS	F exp.	F tab.	Ŋ, %	Sign.
	Genotype - factor A	16504.1	19	868.6	1434.4	2.6	51.5	***
	Environment - factor B	8351.5	2	4175.8	6895.7	7.3	26.1	***
SV	Interaction – A x B	7103.4	38	186.9	308.7	2.1	22.2	***
	Error	72.7	120	0.6			0.2	
	Total	32031.7	179				100	
	Genotype - factor A	188549.8	19	9923.7	4948.1	2.6	45.0	***
	Environment - factor B	91876.3	2	45938.1	22905.4	7.3	21.9	***
FN	Interaction – A x B	138113.0	38	3634.6	1812.2	2.1	33.0	***
	Error	240.7	120	2.0			0.1	
	Total	418779.8	179				100	

SS - sum of squares; gf - degrees of freedom; MS - variance; F exp. - F experimental; F tab. - F tabular; ŋ - effect of influence of the factor (%), *** - significant at *P*<0.001

terion is based on the reliability of the differences in the values of the studied trait and the variance of the interaction with the environment. Here, the genotypes are arranged in descending order according to their economic value.

In our research, the lines RU 32/2072.73.74, RU 47/3504, RU 49/2300, RU 93/1895 and the variety Sadovo 1 - St can be indicated as valuable. The mentioned genotypes are characterized by high and stable values of the sedimentation value during the study period, and in the lines RU 32/2072.73.74 and RU 47/3504, an excess of the characteristic compared to the standard was also observed.

Table 5 presents the results of the stability of the studied breeding materials with the fermentation number trait. It is clear from the data that according to the stability variances (σi^2, Si^2) and Wricke's equivalence (Wi), we can distinguish the lines RU 47/3504, RU 47/2852, RU 91/1748, RU 49/2300 as unstable genotypes according to the investigated trait. The mentioned samples exhibit instability of linear and non-linear type with mathematically significant values of σi^2 and of Si^2. Characteristic of these breeding materials is the strong variation of the trait fermentation number in different years.

We can point out the lines RU 76/1332, RU 128/2900, RU 93/1895 RU 82/1476 and the Sadovo 1 standard as stable traits according to studies. Their stability has been mathematically significant and is of linear and non-linear type. In these genotypes, no great differences were observed in the values of fermentation number in individual years.

According to the generalized criteria for stability of the YSi indicator, as a valuable breeding materials we can indicate the lines RU 91/1729 and RU 32/2072.73.74. The characteristic of these lines is the relatively high reported values of the trait and their demonstrated stability throughout the study period. An excess of the sign compared to the level of the Sadovo 1 Standard is also observed.

Table 4. Stability of the trait sedimentation value

№	Variety	SV, $\bar{x}$	σi^2	Si^2	W_i	YS_i
1	Sadovo 1-st	50.2	180.7 **	340.3 **	350.2	12 +
2	RU 33/3244	48.6	187.6 **	357.2 **	362.7	10 +
3	RU 79/1419	29.7	147.6 **	286.3 **	290.6	-9
4	RU 47/3504	55.3	106.3 **	208.3 **	216.3	14 +
5	RU 76/1321	38.3	954.6 **	1810.3 **	1743.3	-1
6	RU 49/2300	50.2	23.4 **	44.0 **	67.1	13 +
7	RU 129/3053	46.0	15.6 **	29.9 **	53.0	9 +
8	RU 48/2553	38.6	276.2 **	552.9 **	522.1	0
9	RU 76/1332	34.7	36.5 **	71.8 **	90.7	-3
10	RU 79/1370	34.3	238.7 **	477.7 **	454.6	-5
11	RU 47/2852	45.3	1027.1 **	2055.0 **	1873.9	7 +
12	RU 91/1748	26.1	157.9 **	314.0 **	309.3	-10
13	RU 79/1373	34.1	97.2 **	190.9 **	200.0	-6
14	RU 128/2900	45.8	896.2 **	1731.6 **	1638.1	8 +
15	RU 77/878	32.1	32.0 **	64.1 **	82.7	-7
16	RU 82/1476	30.7	-12.2 ns	-23.9 ns	2.9	0
17	RU 79/1383	34.7	1.3 **	2.7 **	27.4	-4
18	RU 91/1729	35.9	8.3 **	15.0 **	39.9	-2
19	RU 93/1895	49.0	135.1 **	255.0 **	268.2	11 +
20	RU32/2072.73.74	63.9	482.4 **	958.1 **	893.4	15 +
LSD (P=0.05) = 0.3489572						

SV - sedimentation value (cm^3); σi^2 - stability variance according to Shukla; Si^2- regression deviation variance; Wi - Wricke's ecovalence; YSi - Kang stability criteria

Table 5. Stability of the trait fermentation number (FN)

№	Variety	FN, $\bar{x}$	σi^2	Si^2	W_i	YS_i
1	Sadovo 1-st	68.6	764.2 **	1545.0 **	1860.3	-10
2	RU 33/3244	80.6	1019.9 **	1859.3 **	2320.6	-8
3	RU 79/1419	91.7	2867.5 **	5282.9 **	5646.2	-6
4	RU 47/3504	169.2	32132.3 **	64184.5**	58323.0	13 +
5	RU 76/1321	131.8	3055.1 **	5812.0 **	5983.8	10 +
6	RU 49/2300	109.0	9485.2 **	17315.6**	17558.1	-2
7	RU 129/3053	109.4	1310.2 **	2473.9 **	2843.2	-1
8	RU 48/2553	126.8	1293.3 **	2389.2 **	2812.7	9 +
9	RU 76/1332	102.6	330.0 **	662.3 **	1078.7	-4
10	RU 79/1370	121.0	4225.5 **	7699.9 **	8090.7	7 +
11	RU 47/2852	78.1	11089.3 **	21127.0**	20445.5	-9
12	RU 91/1748	84.3	10693.7**	20070.5**	19733.5	-7
13	RU 79/1373	106.7	3866.5 **	7083.9 **	7444.4	-3
14	RU 128/2900	154.2	568.6 **	1013.5**	1508.2	12 +
15	RU 77/878	125.8	2817.6 **	5494.2 **	5556.5	8 +
16	RU 82/1476	93.7	827.3 **	1493.1 **	1973.9	-5
17	RU 79/1383	111.7	1574.3 **	3007.4 **	3318.5	0
18	RU 91/1729	185.3	3287.9 **	6176.4 **	6403.0	15 +
19	RU 93/1895	133.2	683.0 **	1238.0 **	1714.2	11 +
20	RU 32/2072.73.74	177.1	5050.8 **	9987.9 **	9576.1	14 +
LSD (p=0.05) = 0.342						

FN - fermentation number (min); σi^2 - stability variance according to Shukla; Si^2- regression deviation variance; Wi - Wricke's ecovalence; YSi - Kang stability criteria

CONCLUSIONS

The highest value for the trait sedimentation value was reported for line RU 32/2072.73.74, followed by line RU 47/3504. In the fermentation number with a high value of the trait, the RU 32/2072.73.74 lines stand out; RU 91/1729; RU 93/1895 and RU 128/2900. The influence of the factors genotype, environment and their interaction on the phenotypic manifestation of the studied signs has been significant.

The following lines can be emitted as valuable breeding materials: RU 32/2072.73.74 and RU 47/3504 (high value and stability of the traits of sedimentation value nd fermentation number). RU 49/2300 (high value and stability of the trait sedimentation value). RU 91/1729 (high value and stability of the trait fermentation number).

The mentioned genotypes can be successfully used in selection and improvement work to create new and high-quality varieties of common winter wheat.

REFERENCES

Angelova, T., Dimitrov, E., & Uhr, Zl. (2020). Evaluation of breeding materials of common winter wheat by express methods. Proceedings of the National Scientific with International Participation, *Ecology and Health*, 6-12 (Bg).

Annicchiarico, P. (2002). Genotype x environment interactions:challenges and opportunities for plant breeding and cultivar recommendations (No. 174), food and agriculture organization, FAO Plant.

Antonov, S. (2017). Climate change trends and their impact on agriculture in the Stavropol Territory. *Orenburg State University*, 4(66), 43-46.

Atanasova, D., Dochev, V., Tsenov, N., & Todorov, I. (2010). Evaluation of winter common wheat varieties by grain quality stability. *Agricultural University-Plovdiv, Scientific Paper*s, 55(1), 65-72.

Atanasova, D., Dochev, V., Tsenov, N., & Todorov, I. (2009). Influence of genotype and environments on quality of winter wheat varieties in Northern Bulgaria. *Agricultural Science and Technology,* 1(4), 121-126.

Bondarenko, M. K., & Nazarenko, M. M. (2020). French breeding wheat varieties adaptabiliy for the Ukrainian North Steppe conditions. *Agrology*, 3(4), 193–198.

Boyadjieva, D. (1994). The result of different germplasm using in the wheat breeding program in Bulgarian dry conditions. Evaluation and Exploitation of Genetic Resources Pre-Breeding Meeting of Eucarpia, 15-18 March,1994. Clermon-Ferrant, France.

Carson, G. R., & Edwards, N. M. (2009). Criteria of wheat and flour quality. In: Khan, K.,Shewry, P.R. (Eds.), *Wheat: Chemistry and Technology*, fourth ed. American Association of Cereal Chemists, Inc_AACC International, Inc, St. Paul, USA, 97-118.

Chamurliyski, P., Tsenov, N., Stoeva, I., Doneva, S., & Penchev, E. (2016). Quality of grain and flour of foreign bread wheat cultivars (*Triticum aestivum* L.) under the conditions of south Dobrudzha region, *Agricultural science and technology.* 8(4), 283-288.

Davidyants, E. S., & Eroshenko, F. V. (2017). Curent state. Trends and ways for, production optimization of high – quality grain of winter wheat is Stavropol. Dostizheniya nauki i tekhniki APK. 31(6), 21-26 (Ru).

Filipov, H. (2004). Evaluation of the quality of wheat by the appearance of the grain", Academic edition of the Agricultural University of Plovdiv, 2004.

Galushko, N. A., & Sokolenko, N. I. (2021). The most important selection criteria for grain quality in winter wheat breeding of the Federal State Budgetary Scientific Institution "North Caucasian Federal Scientific Agrarian Center, *Tauride Bulletin of Agrarian Science*, *4*(28), 50-57.

Galushko, N. A., Komarov, N. M., & Sokolenko, N. I. (2019). Grain quality of new winter wheat varieties selected by north-caucasus research agricultural center, North-Caucasus Research Agricultural Center. *Bulletin of Novosibirsk State Agrarian University,* 2, 7-14.

Galushko, N., Taradina, D., & Donets, I. (2021). Grain quality of new genotypes of winter wheat. Agricultural journal, *3*(14), 18-24.

Gromova, S. N., Kostylev, P. I., Skripka, O. V., Podgorny S. V., & Nekrasova O. A. (2020). The study results of the winter bread wheat varieties of the competitive variety testing according to productivity and grain quality. *Agrarian Science*. 2020, (10), 56-59.

Hermuth, J., Leišova-Svobodova, L., Bradova, J., Kosová, K., Dvořáček, V., Prášil, I. T., & Dotlačil, L. (2019). Genetic characterization and evaluation of twenty Chinese winter wheat cultivars as potential sources of new diversity for breeding. *Czech Journal of Genetics and Plant Breeding, 55*(1), 8-14.

Ivanova, D., & Kirchev, H. (2018). Quality of common wheat varieties of different origin, grown in the ecological conditions of Moesia. *Agricultural University - Plovdiv, Scientific papers. Second Student Scientific Conference.* 61(1), 13-18.

Ivanska, M., Paderevski, J., Stepen, M., & Rodriguez, P. C. (2021). Recommendation for the winter wheat variety based on expected environmental performance. *Agriculture*, *11*(6), p. 522.

Iwaki, K., Haruna, S., Niwa, T., & Kato, K. (2011). Adaptation and ecological differen,tiation in wheat with special reference to geographical variation of growth habit and Vrn genotype. *Plant Breeding*, 120, pp. 107-114.

Jaskulska, I., Jaskulski, D., Kotwica, K., Wasilewski, P., & Gałęzewski, L. (2013). Effect of tillage simplifications on yield and grain quality of winter wheat after different previous crops. *Acta Scientiarum Polonorum series Agricultura*, *12*(3), 37-44.

Kang, M., & Magari, R. (1995). STABIL: Basic program for calculating statistics on stability and stability of production. *Agronomy Journal, 87*, 276-277.

Kang, M., (1993). Simultaneous selection for yield and stability in crop performance trials: Consequences for growers. *Agronomy Journal, 85*(3), 754-757.

Kaya, Y., & Akcura, M. (2014). Effects of genotype and environment on grain yield and quality traits in bread wheat (*T. aestivum* L.). *Food Science and Technology*, 34(2), 386-393.

Kazartseva, A. T., Sokol, N. V., & Vlaschik, L. G. (2010). Sedimentation index and its role in grain quality examination. *Methodological guidelines. Krasnodar*, 15.

Kirchev, H., & Delibaltova, V. (2016). Genotypic specific features of common wheat varieties (*Triticum aestivum* L.). Yield and quality of grain. *International Journal For Research In Agricultural And Food Science*, 2 (2), 13–23.

Koteva, V., & Stoeva, I. (1996). Influence of fertilization on the quality of wheat, variety Sadovo 1, grown on leached resin in Southeastern Bulgaria. *Plant Science*, 2, 9-12.

Kovtun, V. I. (2006). Solar activity and selection of winter wheat / V.I. Kovtun, V.I. Medvedovsky. Rostov-on-Don, p. 496.

Mohan, D., & Gupta, R. K. (2016). Exploring phenotypic expression to augment quality of Triticum aestivum and improve selection efficiency, ICAR-Indian Institute of Wheat and Barley Research, Karnal 132 001, *Haryana Indian Journal of Genetics, 76*(2), 144-151.

Moskalets, T. Z., & Rybalchenko, V. K. (2015). Morphology-physiological and biochemical marker of conformation *Triticum aestivum* L. *Scientific Herald of Chernivtsi University. Biology (Biological Systems)*, 7(1), 49-56.

Nazarenko, M., Mykolenko, S., & Okhmat, P. (2020). Variation in grain productivity and quality of modern winter wheat varieties in northern Ukrainian Steppe. *Ukrainian Journal of Ecology*, *10*(3), 102-108.

Parveen, L., Khalil, I. H., & Khalil, S. K. (2010). Stability parameters for tillers, grain weight and yield of wheat cultivars in north-west of Pakistan. *Pakistan Journal of Botany*, *42*(3), 1613-1617.

Pelshenke, P., Hampel, G., Schafet, W., Kleber, W., Ludecke, H., & Heuer, E. (1953). Methodenbuch, Band XV.

Popov, P., & Dimitrov, D. (1979). "Wheat in Bulgaria". Zemizdat.

Pshenichnaya, I. A., & Dorokhov, B. A. (2017). The use of the sedimentation method in assessing the quality of grain lines of a breeding nursery. *Central Scientific Bulletin, 2*(22), 36-37.

Pshenichnaya, I. A. (2015). The study of sedimentation in the breeding material of winter wheat / I.A. Wheat, B.A. Dorokhov // Prospects for the development of modern agricultural sciences. *Collection of scientific works*. 2. 26-29.

Pumpyanskiy, A. Ya. (1971). Tekhnologicheskie svoystva myagkikh pshenits. L.: Kolos, 320.

Rangare, N. R., Krupakar, A., Kumar, A., & Singh, S. (2010). Character association and component analysis in wheat (*Triticum aestivum* L.). *Electronic Journal of Plant Breeding*, *1*(3), 231-238.

Sandukhadze, B. I. (2016). Selection of winter wheat for productivity and quality of varieties. *Leguminous and cereal crops*. 2(18). - S. 14-19.

Semenov, O. G., Divashuk, M. G., Shanjeshapvako, H. G., & Qaid, M. T. A. (2016). Creation of allocytoplasmic wheat genotypes with high quality characteristics of gluten based on marker selection, Agronomy and animal husbandry series, 1, 7-14.

Shukla, G. (1972). Some statistical aspects of partitioning genotype – environmental components of variability. *Heredity*, 29, 237-245.

Stoeva, I., Tsenov, N., & Penchev, E. (2006). Environmental impact on the quality of bread wheat varieties. *Field Crop Studies*, 3 (1), 7-17.

Stoyanova, A., Georgiev, M., Atanasova, S., Emurlova, F., & Mineva, R. (2020). Study of productivity and stability of yield of common wheat varieties, Journal of Mountain Agriculture on the Balkans, 2020, 23 (5), 75-88.

Taghouti, M., Gaboun, F., Nsarellah, N., Rhrib, R., El-Haila, M., Kamar, M., Abbad Andaloussi, F., & Udupa, S.M. (2010). Genotype environment interaction for quality traits in durum wheat cultivars adapted to different environments. *African Journal of Biotechnology*, 9(21), 3054-3062.

Tsenov, N., Atanasova, D., Chamurliyski, P., & Stoeva, I. (2013). Influence of extreme environmental changes on grain quality of winter common wheat (*Triticum aestivum* L.). *Bulgarian Journal of Agricultural Sciences*, *19*(4), 685-690.

Tsenov, N., Atanasova, D., Stoeva, I., & Tsenova, E. (2015). Effects of drought on grain productivity and quality in winter bread wheat. *Bulgarian Journal of Agricultural Science*, *21*(3), 592-598.

Tsenov, N., Stoeva, I., Todorov, I., & Belchev, I. (2011). Combining ability of cultivars in relation to breeding for grain quality of winter bread wheat. *Agricultural Science*, *44*(3) 29-36.

Uhr, Zl., & Samodova, A. (2020). Agrobiological study of modern varieties of common winter wheat for the Pazardzhik region in southern Bulgaria. *Rastenievadni nauki*, *57*(1), 27-31 (Bg).

Uhr, Zl., Dimitrov, E., & Delchev, G. (2021). Characteristics of perspective lines common winter wheat.1. Yield and stability. *Rastenievadni nauki*, *58*(4) 3-10 (Bg).

Vogel, E., Donat M. G, Alexander, L. V., Meinshausen, M., Ray, D. K., Karoly, D., Meinshausen, N., & Frieler, K. (2019). The effects of climate extremes on global agricultural yields. Environ Research Letters, 14(5), 054010.

Wricke, G. (1962). Über eine Methode zur Erfassung derekologischen Strekbreitein Feldersuchen. *Pflanzenzucht*, 47, 92-96.

Zecevic, V., Kneževic, D., Boškovic, J., & Madic, M. (2009). Effect of genotype and environment on wheat quality. *Genetika, 41*(3), 247-253.

Received: Mart, 20, 2023; Approved: April, 24, 2023; Published: October, 2023